BULGARIAN ACADEMY OF SCIENCES

SPACE RESEARCH IN BULGARIA, 4

Sofia . 1983

Asymmetry in Irregularity Distribution of Both Hemispheres Obtained by Spherical Ion Traps and Langmuir Probes

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Introduction

The different irregularity characteristics in charged thermal particles density have been studied recently in a series of papers using various methods. Radio scintillation observations [1, 2] give a good possibility to study the temporal variations of the irregularity regions at a given point of the Earth, as well as their relation with the geomagnetic activity. Satellite use enables the planetary study of irregularities and the direct measurement of the amplitudes and the scale sizes of the ionospheric irregularities. Using the data from the Langmuir probe on Alouette-2, Dyson [3] describes the equatorial and the polar boundary of the high latitudinal irregularities. McClure and Hanson [4] show different types of ionospheric irregularities, using results obtained by retarding potential analyser on OGO-6. The spectral characteristics of the different types of irregularities are examined in [5] and they are shown to be equal for the irregularities both in high latitudes and in equatorial region. Sagalyn et al. [6] describes diurnal and seasonal changes of high latitudinal irregularities and the difference in both the hemispheres, using spherical electrostatic probe. Ozerov [7] examines the probability of irregularity appearance in dependence on the geomagnetic latitude and the geographic one also with the help of spherical electrostatic probe. It is shown that for given irregularity amplitudes, the calculated ratio scintillation index, applied to the equatorial region latitudes, shows good coincidence with experimental data [8].

Several theories for the interpretation of irregularities appearance have been suggested [9, 10, 11], but the difference in methods and the relatively poor data made difficult the theoretical interpretation.

This paper treats the diurnal variations of the high latitudinal irregularities in the Northern and Southern hemispheres. Results are based on measurements on positive ion density with spherical electrostatic probe and the Langmuir probe data from Intercosmos-8 [12] are used for comparison.

Experiment

Intercosmos-8, launched on Dec. 1, 1972 has initial apogee of 676 km over the South pole and perigee of 215 km over the North pole. The orbit changes relatively fast, and by the end of January 1973 the orbit has apogee of 446 km in the Northern hemisphere, and perigee of 192 km in the Southern hemisphere close to the equator. This enables the observation of ionospheric phenomena at different altitudes within a short period of time. Measurements of about 120 orbits have been used within the period Dec. 3, 1972, Jan. 27, 1973.

Description of some equipment installed on Intercosmos-8 and of some results obtained by the equipment, are given in [13, 14, 15, 16]. In order to measure irregularities in the ion concentration, with respect to the satellite body negative voltage 5V is supplied to the outer grid of the probe for a period of about 3 s. The following 3 s a swept voltage is supplied, and during that period the concentration is measured. This mode of operation is repeated each 6 s. The high negative potential assures work in regime of saturation and collector current fluctuations depend strongly on the change of ion concentration.

Bit level sensitivity in irregularity mode depends on concentration and for 5×10^{5} cm^{-3} it is 5%, respectively for 4×10^{4} cm^{-3} it is 15%. Irregularity space dimensions, which can be recorded, are within limits of 2-20 km.

Parallel to that, the behaviour of ion concentration measured by Langmuir probe is observed. Because of the fact that the Langmuir probe works 1 s per each 9 s cycle, the characteristics of the upper irregularities cannot be obtained, but in the irregularity zone great scatter of electron concentration value is always observed.

Using collector current records, the sizes and the relative amplitude of the irregularities have been evaluated, and a comparison with data from [5] has been made. Regardless of the different way of parametric determination and the greater scatter, the same linear dependence between dimensions and relative amplitude with slope close to 1 is observed.

Diurnal Variations of Irregularity Appearance Limits in Polar Regions

In order to study the diurnal dependence ot irregularity appearance, we divided them into 3-hour intervals by local time, respectively for relatively quiet geomagnetic conditions — $k_p \leq 3$, and disturbed conditions — $k_p > 3$. In this way, the equatorial boundary of high-latitudinal irregularities, shown on Fig. 1 (solid line), have been determined. This was done for both hemispheres, at different geomagnetic situation.

In the Northern hemisphere (Fig. 1*a*) the equatorial boundary at $k_p \leq 3$ is poleward during noon hours at about 70° invariant latitude and is most remote from the pole during night hours 21-24h and predawn hours 03-06h. The same behaviour is maintained under increased geomagnetic activity — $k_p > 3$, as the equatorial boundary generally shifts to the equator, on the average by 3° (Fig. 1*b*). Satellite height changes in this region from about 210 to 440 km. Data on sector 06-09 are not available.

In the Southern hemisphere (Fig. 1*c*) the boundary at $k_p \leq 3$ is poleward during noon hours, at about 75° invariant latitude, and most remote from the pole during night hours 21-03h, at about 60° invariant latitude. Data on the

Southern hemispere and on $k_p>3$ are insufficient, but show the same dependence (Fig. 1*d*). It is interesting to note that in the Southern hemisphere the equatorial boundary in predawn sector 03-06h is obtained for all k_p very close

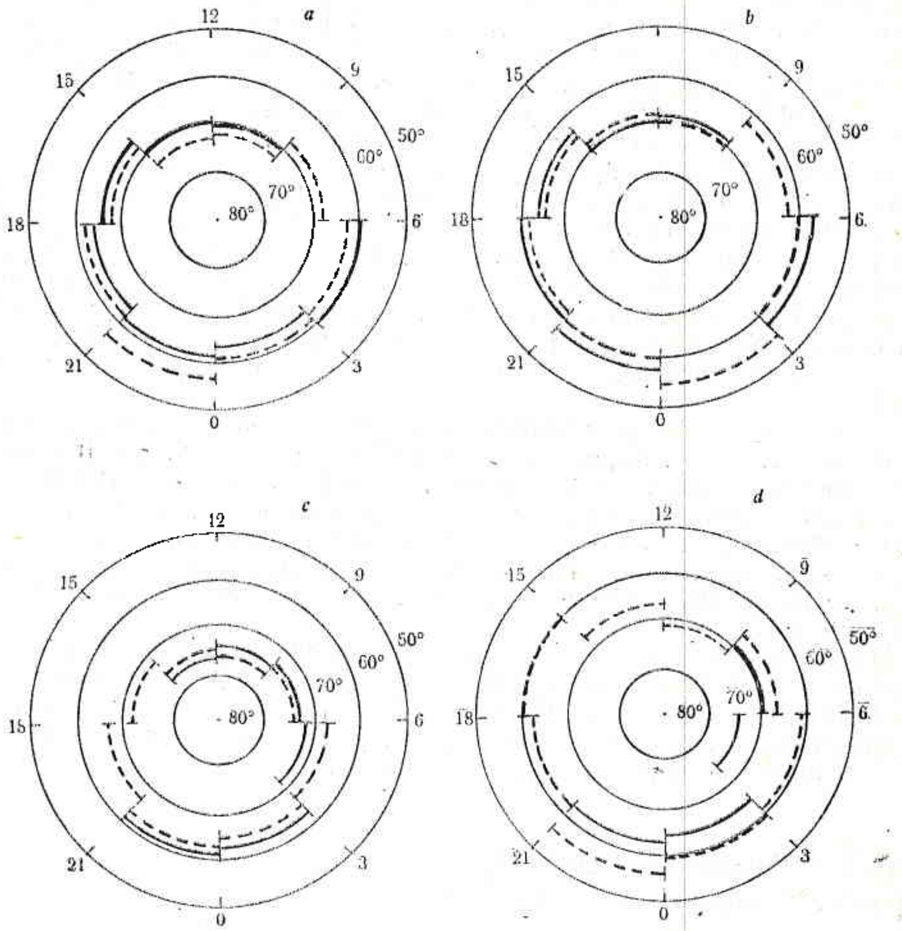

Fig. 1. Equatorial boundary of high-latitudinal irregularities (solid line). It is given for the Northern hemisphere at $k_p\leq3$ (*a*) and at $k_p>3$ (*b*), as well as for the Southern hemisphere at $k_p\leq3$ (*c*) and at $k_p>3$ (*d*). The equatorial boundary of the irregularities obtained under the same conditions by Sagalyn et al. [6] is also shown (dashed line)

to the pole at about 72° invariant latitude. Satellite altitude changes from 270 to 650 km.

Poleward from the equatorial boundary, irregularity records were not always continuous. As a rule, we have observed simultaneous concentration decrease and irregularity disappearance in the midlatitudinal trough, around its minimum.

In the Northern hemisphere irregularity disappearance is observed at about 73° invariant latitude, but there are orbits in which irregularities in greater latitudes are continuously available. In the Southern hemisphere, irregularities have been observed up to 80° invariant latitude during predawn hours.

Asymmetry in Both Hemispheres

The comparison between the equatorial boundaries of the high latitudinal irregularities, at $k_p \leq 3$ in both hemispheres, shows that in the Southern hemisphere the boundary is situated more poleward than in the Northern hemisphere, as during night hours the two boundaries almost coincide (Fig. 2). The difference during noon hours is about 5° invariant latitude. The predawn sector 03-06h is a particular case, where the difference is the greatest — 13° invariant latitude. The asymmetry obtained in the equatorial boundary agrees with the results obtained previously in [6]. This shows that this asymmetry in irregularity distribution in both hemispheres is probably due to differences in the physical conditions generating these irregularities.

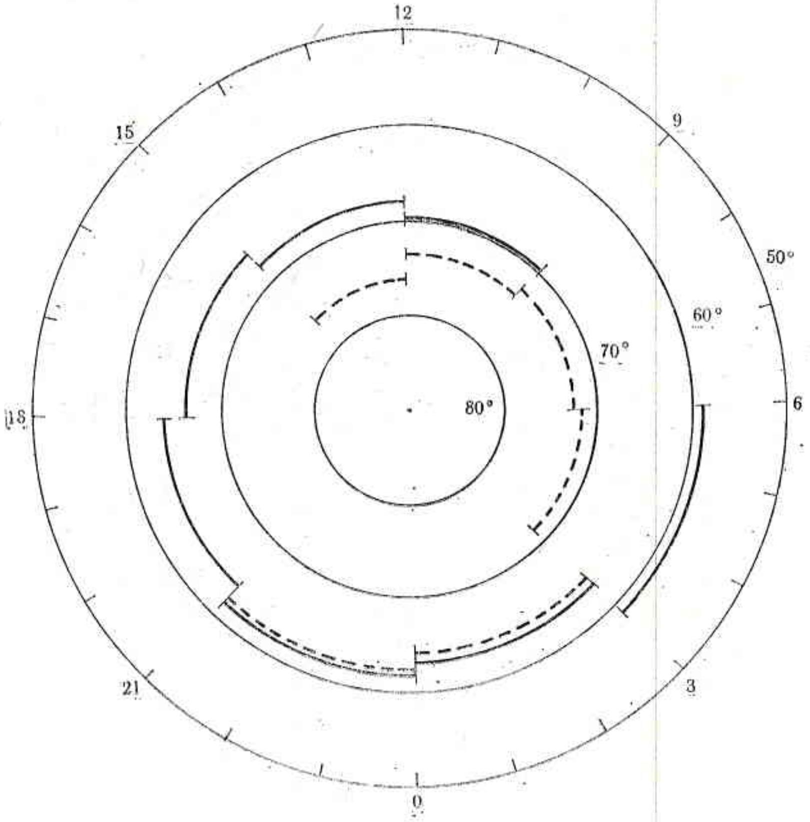

Fig. 2. Comparison between the equatorial boundary of high-latitudinal irregularities in the Northen hemisphere (solid line) and in the Southern hemisphere (dashed line) at $k_p \leq 3$

Discussion

Results obtained here are in good agreement with the results of other authors. The equatorial boundary of high latitudinal irregularities, which have been determined in a similar way by S a g a l y n et al. [6], is plotted on Fig. 1 with a dashed line. Differences might be due to several reasons, e. g. to different instruments. Difference in altitudes of ISIS-I transits (225-3526 km) and Intercosmos-8 (210-650 km) might also contribute to the differences in equatorial boundaries of the irregularities.

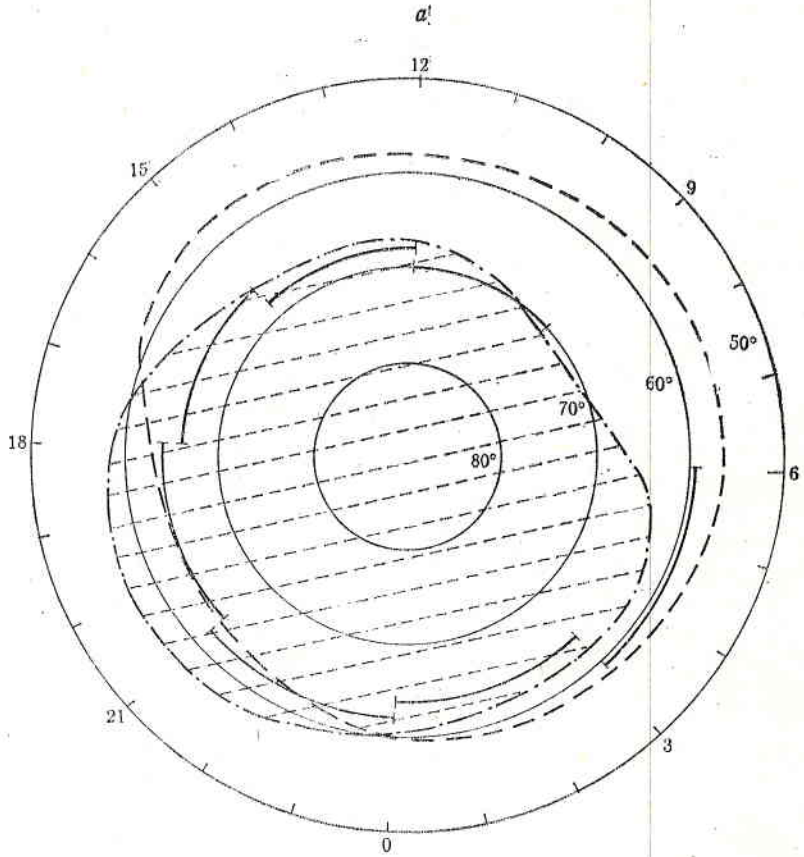

Fig. 3

a — Comparison between the equatorial boundary of irregularities with radio scintillation regions [2] (stroked) and with plasmapause situation [17] (dashed line);

Irregularity absence in the midlatitudinal trough as well as in greater latitudes can be explained easily by taking into consideration the fact that the instrument sensitivity is about 10%, and the relative amplitude of irregularities in midlatitudinal trough is less than 1 per cent [4]. The same reference shows similar decrease up to 3% in high latitudes of about 80° invariant latitude.

The comparison between the radio scintillation boundary at $k_p = 0 \div 1$ in [2] with irregularity boundary at $k_p \leq 3$ in the Northern hemisphere shows satisfactory coincidence, especially when taking into consideration the different geomagnetic situation and that the radio scintillation boundary is determined as latitude, at which the mean scintillation index at 40 MHz is 50%. Especially good is the coincidence during day hours (Fig. 3*a*). The difference is maximal in local time interval 18-21h, where it is about 6° invariant latitude.

At the same Fig. 3*a* shows the comparison between plasmapause situation $k_p \leq 3$, taken from [17] with the obtained irregularity equatorial boundary, at the same quiet geomagnetic situation for the Northern hemisphere. A good coincidence of both boundaries is observed during night hours 18-06h, while

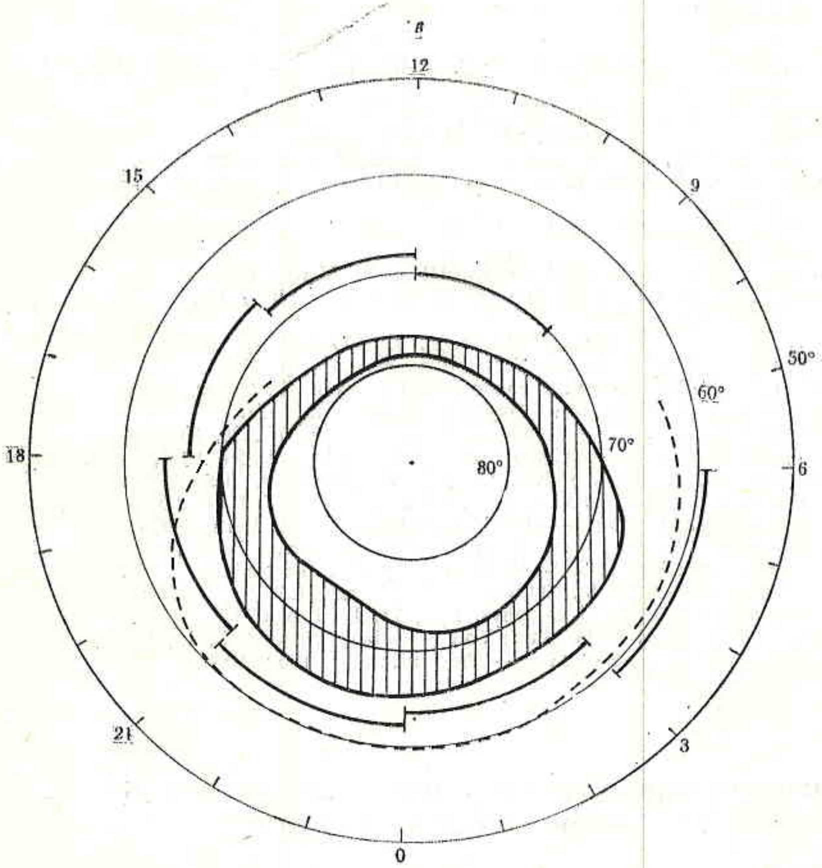

Fig. 3

b — Comparison between equatorial boundary of irregularities with midlatitudinal trough [19] (dotted line) and with auroral oval

there is rather great difference during day hours, appearing till 12° invariant latitude at the local noon.

Figure 3*b* shows the comparison between the irregularity equatorial boundary by Intercosmos-8 measurements, with the auroral oval taken from [18], also for the Northern hemisphere for $k_p \leq 3$. The equatorial boundary of the auroral oval is situated more poleward than the equatorial boundary of high latitudinal irregularities as the difference is maximal during day hours at about 9° invariant latitude, and is minimal at about 2° invariant latitude at local time 21-00h.

The same Fig. 3*b* shows the electron trough in the Northern hemisphere [19]. In the night intervals of the local time the behaviour of the electron trough coindides with the behaviour of the boundary, which confirms well our observations, i. e. that irregularities appear during night hours, immedietely before midlatitudinal ion trough.

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Асимметрия в распределении неедноpодностей в двух полусферах по данным спутника „Интеркосмос-8“

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(Резюме)

Рассмотрены данные ионной концентрации, полученные от около 120 орбит спутника „Интеркосмос-8“ в период 12. 1972 — 1. 1973 гг. Анализированы данные неоднородностей концентрации и место их появления в зависимости от местного времени и геомагнитной активности. Сделано сравнение данных, полученных в северном и южном полушариях. Результаты исследования сравнены с результатами, полученными другими авторами.